The Evolution of the Geological Survey*

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Early American geology was pre-eminently a science of observation and deduction. After a great amount of information was accumulated, some inductive methods evolved. Finally toward the end of the eighteenth century, laboratory experimentation was developed. Progress was due to self-trained men or men untrained in observation, although these men were mostly members of the so-called "learned" professions. For the most part, the early geologists were unable to grasp the true picture necessary to form hypotheses and from analogies to draw general conclusions or formulate laws applicable to the larger question of earth history.

The Maclurean Era, 1785-1819

Indeed American geological history opens in the midst of a great controversy between two European schools of thought, both of which had a profound influence on American geology—Gustav Werner, a German, and his followers believed that the rocks of the earth's crust were the results of a gradual precipitation from the waters of a universal ocean. These men were aptly grouped together as the Neptunists. James Hutton, an Englishman, and his followers, the Plutonists, believed that the oldest or primitive rocks were of igneous origin and the stratified rocks were mechanical deposits. It was in the midst of these two diametrically opposed schools of thought that the first geologic work in America was conceived.

In 1787, at the close of the American Revolution, Johann David Schopf's work was published after a tour through the eastern United States. In this paper, he recognized the Fall Line but could not understand the lack of sedimentary rocks in the Piedmont Region while stratified rocks were present to seaward and to the landward of the above-mentioned region.

This was the period in which the geologist was bent on finding evidence of catastrophic events whether it was present or not, i. e., active volcanoes along the Mississippi River and in New England, earthquakes of all sizes. Maclure took exception to some of the fantastic views on earthquakes, but failed to offer anything satisfactory in return. He wrote, "All of these speculations are out of the reach of our senses and can be accounted only as amusement for the present."

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In 1809, a notable year in American geology, Maclure's *Observations on the Geology of the United States* with a colored geological map of the region east of the Mississippi River was published. Except for Guottard's mineralogical map of Louisiana and Canada, published in 1757, it was the earliest attempt at a geological map of America and has caused its author to be known as the father of American geology and the William Smith of America.

During this period both Benjamin Franklin and Thomas Jefferson wrote articles in the realm of geology and vetebrate paleontology. It has even been inferred that Thomas Jefferson may have been a great president because he studied and worked with vetebrate fossil remains during the time when the rest of young America's populace were ensnarled in the historical events of that day.

Until 1802, when Benjamin Silliman was elected professor of chemistry and natural science at Yale, none of the sciences was taught in the colleges and other institutions of learning in America or England. Indeed the general trend of public opinion was decidedly against the study of geology or the investigation of any question which might lead to the discovery of supposed inconsistencies in the Mosaic account of Creation or to conclusions in any degree out of harmony therewith.

The Eatonian Era, 1820-1829

In 1818, Amos Eaton, a converted lawyer, was destined to achieve national reputation. He abandoned his law practice to attend Silliman's lectures on mineralogy and geology and later traveled many thousands of miles by foot over New England and New York delivering lectures. At Williams College, his Alma Mater, he delivered several lectures. Such was the zeal at this institution, he wrote, that "an uncontrollable enthusiasm for natural history took possession of every mind, and other departments of learning were for a time crowded out of college." On the invitation of Governor DeWitt Clinton, Eaton lectured before the State Legislature at Albany, New York. Here was undoubtedly the beginning of the work which resulted in the establishment of the State Survey in 1836.

The period that may be with propriety called the dark ages of geology was that prior to the discovery and general recognition of the value of fossile in stratigraphy. Although European geologists recognized this as early as 1779, the first American geologist, Dr. S. C. Morton in 1828, took up the matter with an apparent full appreciation of its possibility. The interim which elapsed between the European and American recognition of the possibilities is indeed odd when one recalls the avidity with which each new suggestion is seized upon by the student of today. In 1829, Vanuxem set forth one of the most important generalizations that has thus far been made by any American geologist. "The analogy or identity of rocks, I determine by their fossile in the first instance and their position and mineralogical characters in the second and last instance."

State Surveys, First Decade, 1830-1839

The decade beginning with 1830 stands out prominently as an era of public surveys. With the exception of a single immature attempt in North Carolina in 1824 no survey at other than private expense had thus far been undertaken, though the subject had more than once been agitated. State Surveys were organized as follows:

Massachusetts	1830
Tennessee	1831
Maryland	1831
New Jersey	1835
Connecticut	1835
Virginia	1835
Maine	1836
New York	1836
Ohio (1st organization)	1836
Pennsylvania	1836
Delaware	1837
Indiana	1837
Michigan	1837
New Hampshire	1839
Rhode Island	1839

Men connected with the above surveys were H. D. Rogers,

S. P. Hildreth, W. W. Mather, Douglas Houghton, W. B. Rogers, Ebenezer Emmons, and Lardner Vanuxem.

The Federal Government recognized the practical utility of the geologist by authorizing some surveys in specific areas.

State Surveys, Second Decade, 1840-1849

After 1840, the fever for State Surveys, so prevalent during the 1830's, very quickly subsided. Only three surveys were organized during the second decade:

South Carolina	1843
Vermont	1844
Alabama	1848

The cause of this sudden cessation is not quite apparent but could be due to the depression of 1836, and also to the lack of geologists to agitate the subject and carry on the work. This period was nevertheless, one of importance and one of manifest results rather than of organization and preparation. The volume of literature was naturally greater than at any previous period since it included many of the reports of organizations of the previous decade. Among the names which were to appear prominently will be found those of E. T. Cox, J. P. Lesley, F. B. Meek, B. F. Shumard, Michael Tuomey, and J. D. Whitney.

State Surveys, Third Decade, 1850-1859

During the third decade, several new states authorized geological surveys:

First Attempt:

Mississippi	1850
Illinois	1851
Missouri	1853
Wisconsin	1854
Kentucky	1854
Iowa	1855
Texas	1858
California	1860

Second attempt:

North Carolina	1851
New Jersey	1854
Tennessee	1854
South Carolina	1855
Vermont	1856
Michigan	1859

The Federal Government was also active, the most important undertaking being surveys in connection with the proposed Pacific railways.

This was an era of publication not merely of State survey reports, but also of books and general treatises.

State Surveys, Fourth Decade, 1860-1869

The period of the Civil War naturally might be expected to be a period of uncertainty and inaction in matters relating to the sciences. In all of the seceding States, work then in progress was brought abruptly to a close, and in several of them—Missouri, North Carolina, and Texas—the records became so far lost or ruined through neglect as to make them well-nigh valueless for future reference. Throughout the North, the results were less disastrous, although the work in some instances temporarily discontinued owing to the failure of legislatures to make the necessary appropriations. In the midst of threatened disaster, the following surveys were re-established: California, Maine, New Jersey, and New Hampshire.

With the passing of these years of turmoil, active work was begun once more in the states where it had been temporarily suspended. In other states new organizations were authorized, as in:

Kansas	1864
Iowa	1866
North Carolina	1866
Indiana	1869
Louisiana	1869
Michigan	1869
Ohio	1869
	1869

This was an era in which little was published and a whole host of new workers entered the field, such as: E. H. Hitchcock, Edward Orton, N. S. Shaler, C. A. White, and Alexander Winchell.

State Surveys, Fifth Decade, 1870-1880

Although matters were rapidly shaping themselves in favor of a more comprehensive system of surveys than could be carried on unassisted by the individual states and territories, a number of State surveys were started or revived during this period:

Second Ohio Survey	(Newbury)	1869
Wisconsin (revived)		1873
Alabama (revived)		1873
Second Kentucky Survey		1873
Second Pennsylvania Survey	(J. P. Lesley)	1878
Georgia (started)		?

Important workers in the field in this period were T. C. Chamberlain, J. W. Dawson, W. C. Kerr, E. A. Smith, and J. D. Whitney.

As can be seen in the summary just presented, the history of the State survey up to the turn of the century was erratic, and probably no state has maintained a continuous survey since the first was organized in 1830.

At the present time, all states except two (Maine and Delaware) which were oddly enough two of the first to be organized, have surveys. In 1950, the forty-six State Surveys were appropriated $4,145,951.42 to carry on their work. They employed 749 full-time and 316 part-time employees. Of the total, 806 were classified as technical personnel. Of the 779 projects developed in 1950, 308 were concerned with basic geology. A total of 442 technical publications and individual maps were published.

The Era of National Survey

The period of the Civil War had brought to light a number of men in whom the times had developed a power of organization and command. They were, moreover, men of great physical and moral courage. Therefore, willing workers were abundant and Congress was not difficult to persuade into granting the necessary funds. Hence expedition after expedition was organized and sent out, some purely military, some military and geographic with geology only incidental, and others for the avowed purpose of geological and natural history research.

Under the above conditions, there was inaugurated the work which culminated in 1879, in the organization of the present United States Geological Survey which for breadth of scope and financial resources is without counterpart in the world's history of science.

In 1867, after several trips in the western United States and acting under the general land office, F. V. Hayden, father of the United States Geological Survey, spent several summers doing reconnaissance types of surveying in the west. The results were reported in the Geological and Geographical Survey of the Territories.

The Sioux Indians gave Hayden the name "The-man-who-picks-up-rocks-running." At one time after a long pursuit, a band of hostile Indians overtook him. Finding him armed only with a hammer and carrying a bag of rocks and fossile, which they emptied and examined with much surprise and curiosity, they concluded he was insane and let him alone.

From 1867-1877, there was established by Congressional action under Clarence King, what has since been known as the Geological Survey of the Fortieth Parallel. It is impossible to summarize the topographic and geologic work carried on during this time, except in passing to state that a grand total of 120,000 feet of sedimentary accumulation was studied in the west.

From 1869-1877, Lieutenant C. M. Wheeler, of the United States Engineers, was authorized to undertake a military reconnaissance for topographic purposes in southwest Nevada and western Utah. The work is now known as the United States Geological Survey West of the One Hundredth Meridian. It is noteworthy that two men, G. K. Gilbert and J. J. Stevenson (famous geologists), were attached to this group.

From 1874-1880, J. W. Powell carried on geologic and geographic studies in the Rocky Mountain Region. On March 6, 1879, these Federal Surveys were consolidated into the United States Geological Survey under the Department of the Interior. In 1949, the United States Geological Survey received an annual appropriation amounting to some $28,000,000 and employed 5,871 persons (3,148 classified and 2,723 unclassified).

The West Virginia Geological Survey

In 1947, the West Virginia Geological Survey celebrated its first 50 years of service to the people of the State of West Virginia. The Legislature authorized its organization on February 26, 1897, with the general purpose:

1. To make both general and detailed investigations of the State's geological and physical resources, and

2. To make available to the public promptly and in the most efficient manner, the results of these investigations.

The close relationship existing between the State Geological Survey and the University's Department of Geology makes it impossible to consider the history of one without including the other.

As early as 1867, requests to the Legislature for the establishment of a geological survey were made. It was during this period that J. J. Stevenson's mastery of the subject, his personal magnetism and friendly interest in people influenced one of his students, I. C. White, at the West Virginia University, to center his efforts on geology rather than medicine. Although from the time of the University's founding, courses in geology were included in the curriculum, it was not until 1880 when I. C. White began his professional career that what is known as "strictly geology" was introduced. From 1880 until 1888, when he was joined by Samuel B. Brown, White was head of the Geology Department. During the time that Professor Brown headed the Department, 1894 to 1926, he taught the general courses in physical and historical geology and mineralogy. Brown's thirty-three years of service as Professor and head of the Department of Geology at the University were to the Department what White's thirty years as State Geologist were to the Survey. To date, the following men have served as State Geologist of West Virginia:

I. C. White, State Geologist from September 23, 1897 to November 25, 1927;

D. B. Roger, Assistant Geologist in charge from November 26, 1927 to October 2, 1929;

C. McC. Lemley, State Geologist from October 3, 1929 to March 7, 1930;

R. C. Tucker, Assistant Geologist in charge from March 8, 1930 to June 30, 1930;

James D. Sisler, State Geologist from July 1, 1930 to October 1, 1934;

Paul H. Price, State Geologist from October 1, 1934 to the present;

R. C. Tucker, Acting State Geologist from June 27, 1943 to November 14, 1945, while Dr. Price was on military leave.

Seventeen members of the Department's staff have served in part-time or full-time capacities with the Geological Survey.

This co-operation is further evidence of a relationship which has contributed greatly to the development and prestige of both organizations.

The Work of the West Virginia Geological Survey
First Period, 1897-1912

After the Survey was formed, one of the earliest projects consisted of starting a topographical survey of the State. This work was done in co-operation with the United States Geological Survey which supplied the mapping crew and half of the expenses, but with the State later paying a larger percentage. Preliminary studies were made relating to coal, petroleum, natural gas, limestone, clay, iron ore, and salt brine. In 1899, a geologic map of the State was published. In March of the same year, Volume I, *Oil and Gas,* was published. One of the major projects commenced was to make a complete study of the geology of the State by counties.

During this period, the Survey was housed in the old library building of the University with laboratories in the Agricultural Experiment Station, and the office of the State Geologist in the small brick building which stood on the present library court.

Second Period, 1912-1934

This period saw the completion of the early fundamental work in general stratigraphic and topographic mapping. Thus West Virginia became one of the first states in the Union to be entirely mapped topographically. The study of the State's economic geology was extended and the geologic mapping program was expanded to cover the entire State.

It was during these years that the Survey moved first to Mechanical Hall, and upon the completion of the Chemistry building, in 1926, moved into the quarters which it occupied until construction of the Mineral Industries building in 1942.

Third Period, 1934-?

This period, under the direction of the present State Geologist, is still in progress. It was during this period that the change from a reconnaissance type of geological program was made to a program designated to examine more specifically the geology and the physical and chemical properties of the State's natural resources.

The functions of the Geological Survey at the present time may be grouped under three main divisions. They are: (1) Administrative, (2) Field Investigation, and (3) Laboratory Research.

Administrative—Well equipped offices, chemical laboratories, and library are maintained by the Survey. During the past fifty years, fifty major publications, hundreds of special articles, and additional information have been placed in the Survey files. On request, the Survey is ever ready to dispense this information to the public for use. Hundreds of mineral samples are received by the Survey each year and results of analyses or assays are returned immediately. Wherever positive results are indicated, special investigations are instituted.

Services of the Survey are also utilized by the various departments of the State and Federal governments.

Field Investigations—Until 1939, when the County Geologic Reports were completed, field parties were regularly in the field. With the State completely mapped on a scale of one mile to the inch for topography, geology, and soils, the ground work was laid for all types of special investigations. Detailed reports on springs, iron ore and manganese, rock salt and salt brines, limestone, coal, gas, and oil have followed the completion of the county report series.

At the present time work has been begun on a program with the purpose of re-examining the County Reports and of gathering a more detailed knowledge of the rock strata with special emphasis placed on:

1. Historical geology,
2. Estimation of existing coal reserves,
3. Estimation of other economic resources,
4. Secondary recovery of oil.

During the summer months, field parties have been working in the Ohio-Monongahela River drainage areas, and in the near future, the work will be extended southward in the State.

Laboratory Research—In conjunction with the field work, a part of each year is spent in the laboratory. In several types of modern, well-equipped laboratories, general, chemical, mineralogical, petrographical, and paleontological (plant) research is conducted. In the past few years, a well-equipped gas and oil laboratory, including core testing equipment, and a well-equipped modern coal laboratory for the determination of chemical composition, heating value, and other factors have been installed to better serve the people of the State. Our spectrographic laboratory has been in operation for three years. Geiger counter equipment, both laboratory and portable, for the determination of radio active minerals have been in operation for approximately two years.

In the laboratories thousands of complete analyses of coal, gas, limestones, iron ores, glass-sands, clays, waters, and brines have been made. Many more qualitative tests for various minerals have been made on samples submitted by landowners.

In the past two or three years, four outstanding research projects have been started:

1. Secondary recovery methods of oil and gas,
2. Study of roof conditions and the application of roof bolts to satisfy these conditions,
3. Petrographic study of coals,
4. Spore analyses of the coals as an aid in correlation.

Ground Water Co-operative Project

As ground water constitutes a very important resource of West Virginia with the increased use of water in all phases of our modern life, it was deemed necessary that a current inventory of this important resource be made. In July, 1941, in cooperation with the United States Geological Survey, the State Survey began a systematic study of the ground water supply in West Virginia.

A Model State Resource Survey

In the preceding discussion, surveys as they have existed over the past hundred years and some of their accomplishments have been mentioned. In some cases the survey's program is the same as at its inception, but many of the surveys, and particularly the West Virginia Geological Survey, are attempting to keep abreast of the times and become "A Model State Resources Survey."

The Model State Resources Survey is important because it is concerned with the natural resources of the State. The volume of business always has been, and always will be, based on natural resources—the resources of the land, the rocks beneath the surface, the water, and the air. The development of the natural resources of the State and the Nation, and likewise their conservation, is dependent upon the knowledge of what these resources are, how they can best be recovered, and for what they can be used. There is a growing need for better natural resources surveys. In a youthful nation as ours, wholesale extraction and inefficient and wasteful methods of utilization have marked the development of our natural resources. The stage of exploitation is past, and it is necessary to put our natural resources to their highest uses in harmony with economic principles.

Since many of our surveys in their organizational objectives and methods are nearly identical to what they were in the early days when they were founded, it is necessary that an integrated and practical program based on an appreciation of the powers of science and technology and on sound principles of economics should be formulated and set in motion in every State for the purpose of making as complete an inventory of its resources as is possible, of making studies that will point the way to the correction of wasteful practices of recovery, of finding more efficient methods and forms of utilization and of determining wise and effective means of conservation and development.

The authorities in each state are best qualified to adopt basic principles to the conditions therein existing; only certain basic principles affect the functions of probably most, if not all, State Natural Resource Surveys, but will, if heeded, go far in making them successful:

1. A Survey should have a proper motivating viewpoint. Someone has said, "Tell me what your resources are and I shall tell you what your society is."
2. A model Survey must, of course, have a program of research aimed at both basic knowledge and applied knowledge, and shaped and reshaped against a background of continuously improved information concerning the possibilities of the geologic resources of the State.

3. A model Survey should have a staff of personnel of advanced and varied training and experiences in the basic science of geology, physics, and chemistry, and a minor in economics—a staff of persons whose personalities and resourcefulness will enable them to do group research along sound economic lines.
4. The Survey should have a non-political method of appointing its director and its staff so that their positions are permanent as long as they are productive, co-operative, and in sympathy with the proper Survey policy. These specialists should receive adequate compensation.
5. The Survey should have an adequate clerical staff for the purpose of providing prompt replies to inquiries from citizens and others.
6. The Survey should have an efficient filing system for all scientific, technical data, specimens, and maps.
7. The Survey should have the means for prompt publication and distribution of the results of its investigations.

The Model Survey should do the following:

1. A model Survey, dealing with geological resources, should carry on basic studies on the geologic framework of the State.
2. These basic resources should give use to and be accompanied by researches aimed at applying this basic knowledge to economic problems.
3. The Survey should furnish technical and scientific information on the results of its researches to all who are interested.
4. If a base map has not been made of the State, the Survey should prepare an accurate base map of the State, suitable for the mapping of the resources.
5. Through an educational extension program, the Survey should make available to the citizens, industrialists, consumers, and teachers facts regarding the results of the researches, the resources of the various parts of the State and the possibilities of improved or new utilization.

In concluding these remarks concerning the "Evolution of State Surveys" through the past and present, I would like to reiterate that the period of exploitation and waste is past and if a new era of opportunities await the State Surveys in the future, haphazard exploration must give way to a more scientific and rational form of development in which research will be increasingly looked to for new uses or improved uses of materials.